

STATE OF CALIFORNIA  
The Resources Agency  
DEPARTMENT OF FISH AND GAME



STANDING STOCKS OF TROUT IN  
SECTIONS OF INDIAN CREEK, PLUMAS  
COUNTY, 2001

Bay-Delta and Special Water Projects Division

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by

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Bay-Delta and Special Water Projects Division

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## INTRODUCTION

In 1976, the Department of Water Resources (DWR) initiated an instream flow study to identify streams that would benefit from flow enhancement and to assess instream values required to enhance these streams. The Northern District of DWR selected Indian Creek below Antelope Reservoir (Figure 1) as one of the streams to study under this program. Initial flow studies by DWR indicated that flow augmentation could double trout habitat in the first 16 km of Indian Creek below the dam and increase habitat by 25 percent in lower reaches (DWR 1979). As a result of this study, DWR and the Department of Fish and Game (DFG) reoperated Antelope Reservoir beginning in March 1978 to increase flow releases from 0.1 cms to 0.6 cms year-round during normal and wet years to enhance recreation and fishery values (Hinton 1983). Brown (1993) reported that increased flows had increased trout standing stocks and numbers of catchable trout from 1976 through 1993.

Sampling of salmonids was begun in Indian Creek at six different stations in 1977. Sampling continued through 1982 on a yearly basis to provide baseline data for salmonid biomass (Brown 1978, Brown and Haines 1979, Haines and Brown 1980, Villa and Brown 1981, Villa 1982, Bumpass et. al. 1987a). Fish were not sampled in 1983, 1984, or 1985. Sampling resumed in 1986 and continued in 1987, 1988, 1989, 1990, 1995, 1999, 2001 (Bumpass et. al. 1987b, Bumpass and Smith 1989, Bumpass and Brown 1989, Brown 1991a, Brown 1991b, Brown 1993, Brown 1996, Brown 1999, and Brown 2001).

The objective of this study is to estimate the number, age, and growth of trout in previously established stations. The stations were originally established to set baseline conditions with which future changes in seasonal stream flow or other elements of habitat would be compared. A report summarizing fisheries studies on Indian Creek was published in 1993 (Brown 1993).

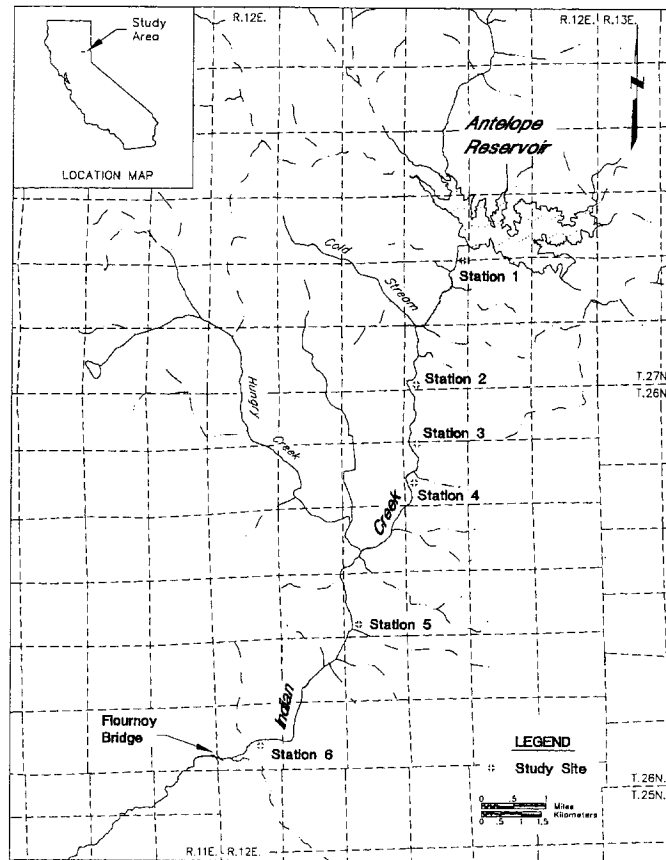


Figure 1 - Map of sampling stations in Indian Creek, Plumas County, 2001.

### STUDY AREA

The Indian Creek study area extends from the stream at the base of Antelope Dam to Fournoy Bridge (Figure 1). The stream flows through rocky canyons and grassy meadows. Elevation in the study area averages 1464 m. Steep hillsides surrounding the stream are covered with pine, cedar, and fir trees. Trees that border the stream are predominantly alder. Indian Creek averages 7m in width in the study area.

Stream flow is a combination of releases from Antelope Dam and inflow from tributaries such as Cold Stream and Hungry Creek. Storms and snowmelt can raise flows to flood levels in February, March, April, or May. Significant flooding occurred in 1982, 1983, and 1986. Summer flow is largely comprised of releases from the dam. Flow is 0.14 cms in very dry years, 0.28 cms in dry years, and 0.6 cms in normal or wet years (Hinton and Haines 1981).

Water quality and benthic organisms were sampled in six stations in 1979 in the study area by personnel from the Water Quality and Biology Unit of the Northern District of DWR. Dissolved oxygen averaged 9.8 ppm while pH averaged 7.3. Alkalinity was 44 mg/L as CaCO<sub>3</sub> while

turbidity averaged 1.2 FTU. Dominant benthic macroinvertebrates were mayflies of the genus Baetis, stoneflies of the genus Hydropsyche, flies of the subfamily Chironominae, and flies of the genus Simulium (Boles 1980).

Species of fishes living in Indian Creek include: rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), golden shiners (*Notemigonus crysoleucas*), Sacramento pike minnow (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), Lahontan redbreast (*Richardsonius egregius*), speckled dace (*Rhinichthys osculus*), Sacramento sucker (*Catostomus occidentalis*), brown bullhead (*Amiurus nebulosus*) and green sunfish (*Lepomis cyanellus*).

## METHODS

### Physical Measurements

Standing stocks of fishes were estimated at six stations in Indian Creek (Figure 1). Stations were intentionally selected to be near stations sampled in previous DFG studies (Gerstung 1973). Stations were selected to represent stream habitat in the proportion it occurs in Indian Creek. Markers were placed in trees along the stream to identify station boundaries. Stations have been sampled in the same locations over the years to allow biological comparisons. Stations varied in length from 36.0 to 59.3 m. The length and width of each station was measured with metric tape measures.

### Biological Measurements

Fish were captured with a battery-powered backpack electroshocker in stream sections blocked by seines as described by Platts et al. (1983) (Figure 2). Captured fish were removed from the net-enclosed section on each pass. Standing stock estimates were developed using the two-count method of Seber and LeCren (1967) or the multiple-pass method of Leslie and Davis (1939) with limits of confidence computed using a formula proposed by DeLury (1951).

The weights of trout and nongame fishes were measured by displacement (Figure 3). Fork length (FL) of each fish caught was measured to the nearest millimeter.

Scale samples were taken from brown trout and rainbow trout over 100 mm in length. Scales were taken just above the lateral line between the dorsal and adipose fin (Scarnecchia 1979) and placed in a piece of paper inserted in a small coin envelope (Drummond 1966). Scales were mounted dry between microscope slides, and their images were projected on a NCR microfiche reader at a magnification of 42x. Scale measurements for the calculation of growth were recorded to the nearest millimeter along the anterior radius of the anterior-posterior axis of the scale. Estimation of instantaneous population growth rate was calculated (Ricker 1975) with significant values of correlation coefficients taken from a table (Steel and Torrie 1960).



Figure 2. Electrofishing in Indian Creek, Plumas County.



Figure 3. Weighing trout by displacement.

Instantaneous population growth rate =  $b (\log_e l_2 - \log_e l_1)$

$b$  = between ages functional slope

$l_1$  = initial length for the last complete year of growth

$l_2$  = final length for the last complete year of growth

Standing crops of brown trout and rainbow trout were calculated for individual stations where each species was caught and then combined for the entire creek. Age and growth was calculated for the population (Everhart et al. 1975). Length-weight relationships were determined for both brown trout and rainbow trout (Lagler 1956). The coefficient of condition and 95 percent confidence intervals were calculated for population estimates of all trout (Carlander 1969).

## RESULTS

### Distribution

Brown trout were caught at stations 1 through 5. Rainbow trout were caught at stations 5 and 6. Sacramento suckers, and Sacramento pike minnows were also caught in station 6 (Table 1).

Table 1. Distribution of fishes in sections of Indian Creek, Plumas County, 2001.

Species	Station Number					
	1	2	3	4	5	6
Brown trout	X	X	X	X	X	X
Rainbow trout					X	X
Sacramento pike minnow						X
Sacramento sucker						X

### Standing Crop

Brown trout were the most common game fish caught in Indian Creek. Biomass averaged  $1.2 \text{ g/m}^2$  at five stations. Biomass for brown trout large enough for anglers to catch and keep (127 mm FL and larger) averaged  $1.0 \text{ g/m}^2$  (Table 2). Rainbow trout biomass averaged  $0.15 \text{ g/m}^2$ , while the biomass for catchable trout also averaged  $0.15 \text{ g/m}^2$  (Table 3).

Table 2. Estimates of brown trout standing crop in Indian Creek, Plumas County, 2001.

Distance below Antelope Dam (km)	Population Estimate	95 percent Confidence Estimate	Biomass (g/m <sup>2</sup> )	Estimate of Catchable Trout	Biomass of Catchable Trout
1.3	7	7-8	0.3	0	0
3.9	39	35-48	1.2	13	1.0
5.3	42	38-50	3.4	19	3.1
6.6	23	23-24	1.7	12	1.6
12.3	32	26-47	0.3	3	0.2
21.0	1	1-1	0.1	0	0

Table 3. Estimates of rainbow trout standing crop in Indian Creek, Plumas County, 2001.

Distance below Antelope Dam (km)	Population Estimate	95 percent Confidence Estimate	Biomass (g/m <sup>2</sup> )	Estimate of Catchable Trout	Biomass of Catchable Trout
12.3	14	13-19	0.2	5	0.2
21.0	4	4-9	0.1	3	0.1

### Length and Weight

Age group 0+ brown trout represented 65 percent of the catch. Ages 1+ and 2+ fish represented 16 percent and 18 percent, respectively, while 3+ fish made up 1 percent (Figure 4). Age group 0+ rainbow trout represented 31 percent of the catch. Ages 1+ and 2+ trout made up 52 percent and 17 percent, respectively (Figure 5).

The relationship between length (L) and weight (W) of brown trout is:

$$\begin{aligned}\log_{10} W &= -4.9 + 3.0 \log_{10} L \\ r^2 &= 0.99 \\ N &= 131 \text{ (Figure 6 and Appendix 2)}\end{aligned}$$

The same relationship for rainbow trout is:

$$\begin{aligned}\log_{10} W &= -4.5 + 3.0 \log_{10} L \\ r^2 &= 0.99 \\ N &= 29 \text{ (Figure 7 and Appendix 3)}\end{aligned}$$

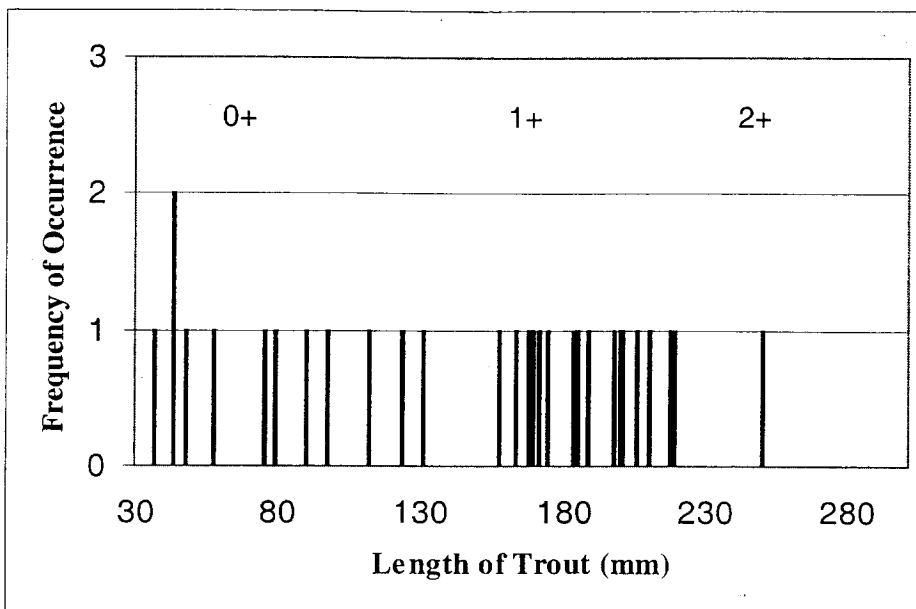


Figure 4. Length, observed frequency, and age of brown trout caught in Indian Creek, Plumas County, 2001.

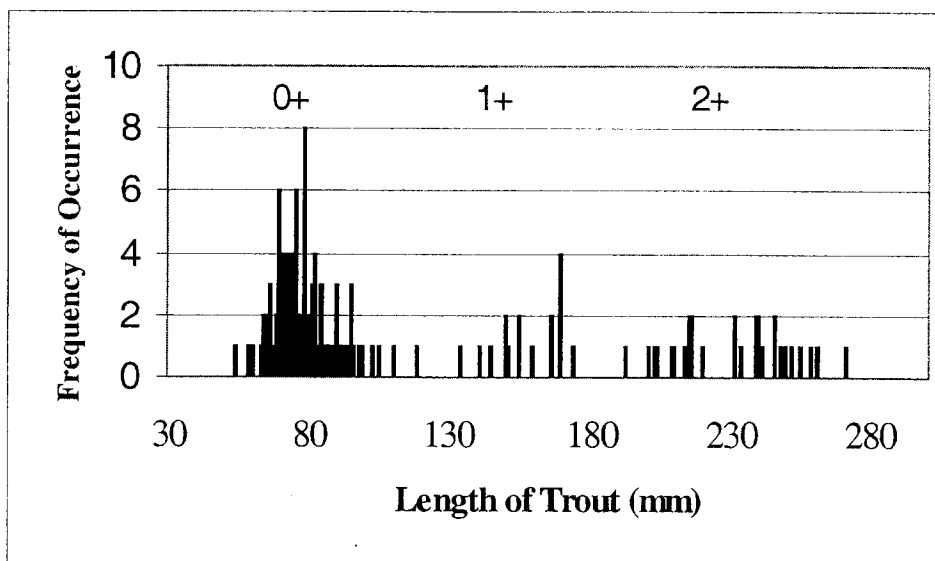


Figure 5. Length, observed frequency, and age of rainbow trout caught in Indian Creek, Plumas County, 2001.

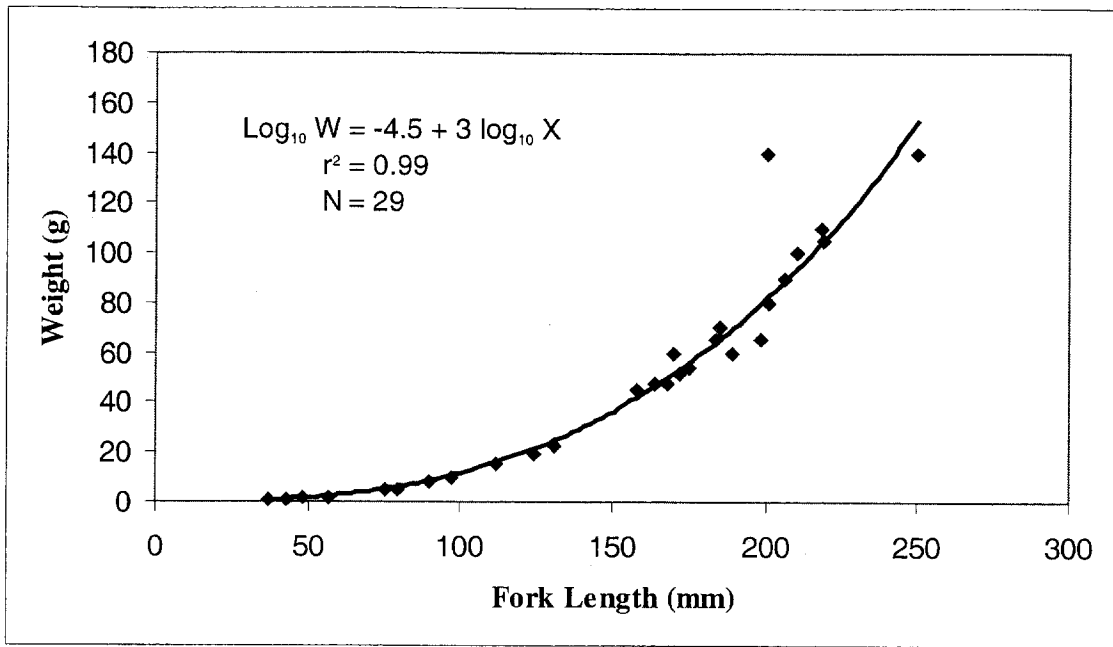


Figure 6. The relationship between length and weight of brown trout caught in sections of Indian Creek, Plumas County, 2001.

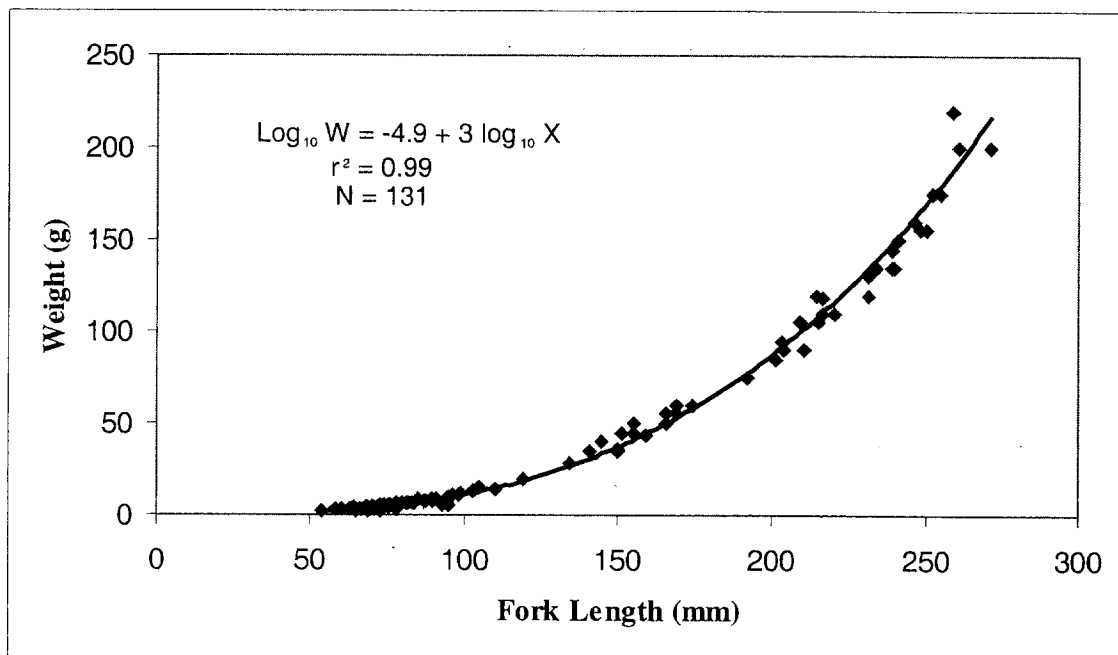


Figure 7. The relationship between length and weight of brown trout caught in sections of Indian Creek, Plumas County, 2001.

## Age and Growth

The formula  $FL = -4.9 + 3.0 S$  describes the relationship between the fork length and enlarged scale radius (S) of 131 brown trout caught in Indian Creek. The coefficient of correlation ( $r^2$ ) is 0.99. The formula was  $FL = -4.5 + 3.0 S$  for 29 rainbow trout caught, while the value for  $r^2$  is 0.99.

The population instantaneous growth rate was greater than the mean individual instantaneous growth rate for age 1+ brown trout (Table 4). Population growth was also greater than mean individual growth in age 1+ rainbow trout (Table 5).

Table 4. Growth rates for brown trout caught in Indian Creek, Plumas County, 2001.

Age Interval	Population Growth			Mean Individual Growth		
	Length Interval (mm)	Difference in Natural Logarithms	Instantaneous Growth Rate $G_x$	Length Interval (mm)	Difference in Natural Logarithms	Instantaneous Growth Rate $G_x$
1-2	96-194	0.704	2.111	110-194	0.567	1.702

Table 5. Growth rates for rainbow trout caught in Indian Creek, Plumas County, 2001.

Age Interval	Population Growth			Mean Individual Growth		
	Length Interval (mm)	Difference in Natural Logarithms	Instantaneous Growth Rate $G_x$	Length Interval (mm)	Difference in Natural Logarithms	Instantaneous Growth Rate $G_x$
1-2	79-158	0.693	2.079	100-158	0.4574	1.372

Age 1+ brown trout averaged 157 mm in fork length; 2+ fish averaged 231 mm (Table 6). Age 1+ and 2+ rainbow trout measured 171 mm and 201 mm, respectively (Table 7).

Table 6. Calculated fork length of brown trout from Indian Creek, Plumas County, 2001.

Age	Number of Fish	Length at Capture (mm)	Calculated Lengths at Successive Annuli	
			1	2
1	19	157	96	-
2	38	231	110	194
Number of back-calculations			57	38
Weighted means (mm)			105	194
Increments (mm)			105	89

Table 7. Calculated fork length of rainbow trout from Indian Creek, Plumas County, 2001.

Age	Number of Fish	Length at Capture (mm)	Calculated Lengths at Successive Annuli	
			1	2
1	10	171	79	-
2	7	201	100	158
Number of back-calculations			17	7
Weighted means (mm)			88	158
Increments (mm)			88	70

#### Coefficient of Condition

We calculated the coefficient of condition and 95 percent confidence limits age 0+, 1+, 2+, and combined ages for a total of 131 brown trout and 29 rainbow trout (Table 8).

Table 8. Condition of brown trout and rainbow trout in Indian Creek, Plumas County, 2001.

Age	Number of Fish	Coefficient of Condition	95% Confidence Interval
Brown Trout			
0+	85	1.1166	0.7619-1.4714
1+	17	1.1863	1.0119-1.3607
2+	29	1.0661	0.9244-1.2078
Combined	131	1.1145	0.8079-1.4211
Rainbow Trout			
0+	9	1.3079	0.6352-1.9805
1+	13	1.0350	0.8403-1.2296
2+	7	1.1146	0.5529-1.6762
Combined	29	1.1389	0.6210-1.6567

Biomass of rainbow trout was below average values for previous years, but the population estimate was average. Biomass and population estimates for brown trout were both below average (Table 9). Brown trout populations have not fully recovered from low streamflow that was a result of drought conditions in the early 1990s. Low summer flows reduced available rearing habitat and limited production. Summer flow and trout habitat are related in Indian Creek (Hinton and Haines 1981).

Table 9. Population estimates and biomass of rainbow and brown trout in Indian Creek, 1977-2001.

Date	Rainbow Trout		Brown Trout	
	Biomass (g/m <sup>2</sup> )	Population Estimate (no/m <sup>2</sup> )	Biomass (g/m <sup>2</sup> )	Population Estimate (no/m <sup>2</sup> )
1977	0.7	0.01	5.7	0.16
1978	0.4	0.01	5.0	0.07
1979	1.2	0.02	4.9	0.42
1980	2.7	0.07	5.8	0.16
1981	0.7	0.01	5.0	0.19
1982	0.4	0.05	4.4	0.09
1986	0.9	0.04	2.8	0.03
1987	2.1	0.01	4.6	0.18
1988	0.3	0.01	5.6	0.67
1989	0.6	0.01	5.7	0.12
1990	2.2	0.02	4.2	0.17
1993	0.5	0.01	4.0	0.07
1995	0.4	0.01	3.9	0.07
1999	1.5	0.02	3.8	0.07
2001	0.2	0.01	1.2	0.03
Mean	1.0	0.02	4.4	0.17

The relationship between summer flow and brown trout populations is highly significant ( $p < 0.01$ ), while the relationship between flow and population of all trout is also significant ( $p < 0.05$ ). Catchable-sized trout greatly benefit from higher summer flows. The correlation between flow and catchable brown and rainbow trout are significant ( $p < 0.01$ ) (Brown 1993).

Biomass and population estimates for brown and rainbow trout were well below average in 2001 (Table 9). These values were low because streamflow in Indian Creek was very low during the spring and summer. Flow during this period was 0.14 cms. Streamflow was so low because little rain or snow fell in the Indian Creek watershed in 2000-2001. Flow in Indian Creek in the summer is usually 0.60 cms during normal or wet years. Low streamflow limits spawning and rearing area for trout in Indian Creek (Hinton and Haines 1981).

Rates of instantaneous population growth were average for brown and below average for rainbow trout in 2001 (Table 10). Growth was average or low because trout were exposed to unfavorable rearing habitat in 2001 as summer flow was 0.14 cms. Growth in Indian Creek could be related to flow because decreased flows decrease useable habitat for the two elements of food production and cover (Hinton and Haines 1981). These two elements influence productivity,

standing crops, and growth (Saunders and Smith 1963, Lewis 1969, Mesick 1968, Wesche et al. 1987, Jowett 1992).

Table 10. Estimates of instantaneous population growth rate (g) of brown trout and rainbow trout in Indian Creek, 2001.

Year	Brown Trout		Rainbow Trout	
	Age Interval			
	I-II	II-III	I-II	II-III
1978	2.214	0.938	-	-
1979	1.394	1.670	-	-
1980	2.086	1.219	-	-
1981	1.850	1.505	-	-
1982	2.029	-	1.541	-
1986	1.777	0.965	1.242	1.151
1987	1.974	1.012	2.080	1.070
	2.616	0.605	1.329	-
	2.288	-	1.856	-
1990	2.154	1.776	2.378	-
1993	2.535	0.981	1.943	-
1995	2.445	1.216	2.144	-
1999	2.048	-	2.188	-
2001	2.111	-	2.079	-
Mean	2.109	1.189	1.878	1.111

## DISCUSSION

The objective of this study has been to estimate the number, age, and growth of trout in previously established stations in Indian Creek. This has allowed us to set baseline conditions with which future changes in seasonal stream flow or other elements of habitat can be compared. We have shown that trout standing crop and growth is less during periods of low flow and greater during periods of higher flow. This confirms studies done by Hinton and Haines (1981) that showed that increased flow in Indian Creek produced more and better habitat for trout. Additional studies should strengthen the relationships between streamflow and trout populations in Indian Creek.

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## APPENDIX 1

### FISH POPULATION STATIONS ON INDIAN CREEK, PLUMAS COUNTY, SEPTEMBER 1999 AT 0.56 CMS

Station	Distance below Antelope Dam (km)	UTM	Length (m)	Area (m <sup>2</sup> )
1	1.3	035 493	36	709.2
2	3.9	025 467	54	1393.2
3	5.3	024 453	39.7	603
4	6.6	010 423	48.2	902.4
5	12.3	009 409	41.2	1143.9
6	21	982 337	59.3	1209.5

## APPENDIX 2

### LENGTH AND WEIGHT OF BROWN TROUT CAUGHT IN INDIAN CREEK, SEPTEMBER 2001

Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
54	2	75	5	95	5.5	231	130
58	3	75	5	95	10	231	120
60	3	75	5	95	10	234	135
63	3	75	5	96	11	239	135
64	4	75	5	98	11	239	145
64	3	76	5	99	12	240	135
65	2.5	77	5	103	13	240	135
65	3	77	4	105	15	241	150
66	3	78	3	110	14	246	160
66	3	78	3	119	20	246	160
66	3	78	5	134	28	248	155
67	3	78	5	141	35	250	155
68	4	78	5	145	40	252	175
68	4	78	6	150	35	255	175
69	2	78	6	150	36	259	220
69	4	78	6	151	45	261	200
69	4	80	6	155	50	271	200
69	3	80	6	155	45		
69	4	81	6	159	44		
69	3	81	6	166	50		
70	4	81	6	166	55		
70	4	82	6	169	55		
70	4	82	6	169	55		
70	4	82	6	169	60		
71	4	82	6	169	60		
71	3	83	7	174	60		
71	4	84	7	192	75		
71	4	84	7	201	85		
72	4	84	6	203	95		
73	2.5	85	9	204	90		
73	4	87	8	209	105		
73	4	88	8	210	90		
73	5	90	9	214	120		
74	5	90	9	215	105		
74	5	90	8	215	105		
74	5	91	9	216	110		
74	4	93	5	216	118		
75	4.5	94	9	220	110		

### APPENDIX 3

#### LENGTH AND WEIGHT OF RAINBOW TROUT CAUGHT IN INDIAN CREEK, SEPTEMBER 2001

Length (mm)	Weight (g)
37	1
43	1
43	1
48	2
57	2
75	5
79	5
90	8
97	10
112	15
124	19
131	23
158	45
164	48
168	48
170	60
172	52
175	54
184	65
185	70
189	60
198	65
200	140
201	80
206	90
210	100
218	110
219	105
250	140